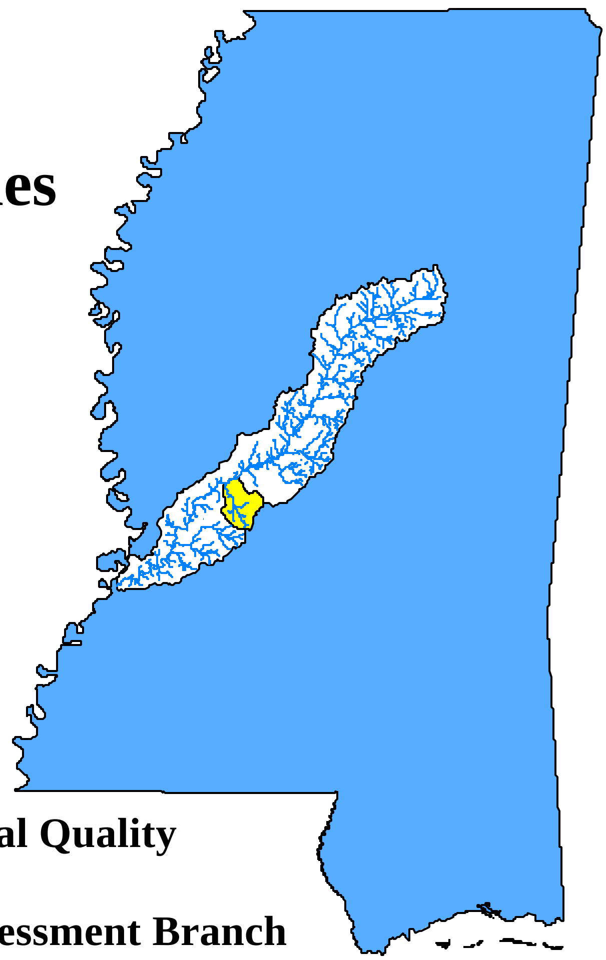
Proposed Version
June 12, 2002

Phase I TMDL
For
Organic Enrichment/Low Dissolved Oxygen And Biological Impairment

Bogue Chitto Creek
Big Black Basin
Hinds and Madison Counties
Mississippi



Prepared By

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FOREWORD

The report contains one or more Total Maximum Daily Loads (TMDLs) for waterbody segments found on Mississippi's 1996 Section 303(d) List of Impaired Waterbodies. Because of the accelerated schedule required by the consent decree, many of these TMDLs have been prepared out of sequence with the State's rotating basin approach. The segments addressed are comprised of monitored segments that have data indicating impairment. The implementation of the TMDLs contained herein will be prioritized within Mississippi's rotating basin approach.

The amount and quality of the data on which this report is based are limited. As additional information becomes available, the TMDLs will be updated. Such additional information may include water quality and quantity data, changes in pollutant loadings, or changes in landuse within the watershed. In some cases, additional water quality data may indicate that no impairment exists.

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TMDL Information Page

Listing Information

Name	ID	County	HUC	Cause	Mon/Eval
Bogue Chitto Creek	MS463M	Hinds and Madison	08060202	Organic Enrichment/Low DO	Monitored
Location – Near Flora: From Tinnin Road including parts of Limekiln and Straight Fence West Ditch to Confluence with Spring Creek					
Bogue Chitto Creek	MS463M	Hinds and Madison	08060202	Biological Impairment	Monitored
Location – Near Flora: From Tinnin Road including parts of Limekiln and Straight Fence West Ditch to Confluence with Spring Creek					

Water Quality Standard

Parameter	Beneficial use	Water Quality Criteria
Dissolved Oxygen	Aquatic Life Support	Dissolved oxygen concentrations shall be maintained at a daily average of not less than 5.0 mg/L with an instantaneous minimum of not less than 4.0 mg/L in streams.

NPDES Facilities

NPDES ID	Facility Name	County	Receiving Water	Flow (cfs)
MS0021849	Baptist Children's Village	Hinds	An Unnamed Tributary of Bogue Chitto Creek	0.093
MS0044644	Catfish Haven Restaurant	Hinds	Limekiln Creek	0.004
MS0047619	City of Clinton – Briars POTW	Hinds	An Unnamed Tributary of Bogue Chitto Creek	0.975
MS0023230	City of Clinton – Lovett POTW	Hinds	An Unnamed Tributary of Straight Fence Creek	0.427
MS0021164	City of Clinton – Northeast POTW	Hinds	Straight Fence Creek	0.464
MS0046647	Southern Oaks Subdivision	Hinds	An Unnamed Tributary of Bogue Chitto Creek	0.062
MS0030295	Jackson POTW (Presidential Hills Subdivision)	Hinds	Bogue Chitto Creek	1.160
MS0043401	Lake Lorman Utility District	Madison	An Unnamed Tributary of Limekiln Creek	0.099

Total Maximum Daily Load

Type	Summer Conditions (May – Oct)	Winter Conditions (Nov – April)	Unit
WLA	408.0	515.8	lbs/day $TBOD_U$
LA	17.3	17.3	lbs/day $TBOD_U$
MOS	(implicit)	(implicit)	lbs/day $TBOD_U$
TMDL	**425.3**	**531.1**	lbs/day $TBOD_U$

EXECUTIVE SUMMARY

Bogue Chitto Creek along with portions of Limekiln and Straight Fence Creeks, have been placed on the Mississippi 1998 Section 303(d) List of Waterbodies as impaired waterbodies. The impairment was detected based on water quality sampling and screening-level biological monitoring. The biological monitoring was conducted in conjunction with a nonpoint source monitoring project that began in 1991. Following assessment of the data collected through this project, Bogue Chitto Creek was placed on the 303(d) List for organic enrichment/low dissolved oxygen and biological impairment. Additional field study was conducted on Bogue Chitto Creek at Highway 22 in August 1999, Photo 1.1. This study confirmed that the creek was impaired due to organic enrichment/low dissolved oxygen. Based on data collected in 1999, MDEQ determined that the biological impairment in the creek is caused by the low dissolved oxygen levels.

A modified Streeter-Phelps dissolved oxygen sag model was selected as the modeling framework for developing the TMDL allocations for this study. The model was developed to account for seasonal variations in stream temperature, dissolved oxygen saturation, and biochemical oxygen demand decay rate. The model used in developing this TMDL includes both point and nonpoint sources of oxygen demanding material. There are nine NPDES permitted point sources in the watershed, eight of which were included in the model. Nonpoint contributions in the watershed were estimated using an assumed background concentration of organic material in the stream.

Photo 1.1. Bogue Chitto Creek @ Hwy 22

This report is being proposed as a phased TMDL Report because the available instream data for Bogue Chitto Creek were collected at a single location. Data collected at this location were sufficient to show that the waterbody was impaired due to low dissolved oxygen levels. However, more data are needed in order to adequately characterize the instream processes that affect the decay rate of organic material and dissolved oxygen use. As a result, the predictive model used to calculate this TMDL is based primarily on assumptions described in MDEQ Regulations.

Wasteload allocations of organic material for the Bogue Chitto Creek Watershed were developed using the model. The NPDES permitted loads of organic material in the watershed are greater than the wasteload allocation. Thus, reductions of the permitted load may be necessary in order to maintain water quality standards in Bogue Chitto Creek. More data, however, are needed to make an accurate assessment of nonpoint sources and verify the assumptions used in the predictive model. Additional data collection activities are planned for the watershed that will allow an accounting of nonpoint sources of organic material in the watershed due to nonpoint sources and urban development. This assessment will be used to develop a Phase II TMDL.

1.0 INTRODUCTION

1.1 Background

The identification of waterbodies not meeting their designated use and the development of total maximum daily loads (TMDLs) for those waterbodies are required by Section 303(d) of the Clean Water Act and the Environmental Protection Agency's (EPA) Water Quality Planning and Management Regulations (40 CFR part 130). The TMDL process is designed to restore and maintain the quality of those impaired waterbodies through the establishment of pollutant specific allowable loads. The TMDL process can be used to establish water quality based controls to reduce pollution from both point and nonpoint sources, and restore and maintain the quality of water resources. The Mississippi Department of Environmental Quality (MDEQ) has identified Bogue Chitto Creek and portions of Limekiln and Straight Fence Creeks as being impaired for a length of 14 miles as reported in the Mississippi 1998 Section 303(d) List of Waterbodies. The impairment is caused by reduced levels of dissolved oxygen (DO) in the Creek due to oxidation of organic material. Thus, this TMDL has been developed for organic enrichment.

Organic enrichment is measured in terms of total ultimate biochemical oxygen demand ($TBOD_U$). $TBOD_U$ represents the oxygen consumed by microorganisms while stabilizing or degrading carbonaceous and nitrogenous compounds under aerobic conditions over an extended time period. The carbonaceous compounds are referred to as $CBOD_U$, and the nitrogenous compounds are referred to as $NBOD_U$. $TBOD_U$ is equal to the sum of $NBOD_U$ and $CBOD_U$, Equation 1.1.

$$\boxed{\mathbf{TBOD_U = CBOD_U + NBOD_U}} \qquad \text{(Equation 1.1)}$$

1.2 Segment Location

Bogue Chitto Creek flows in a northwestern direction from its headwaters near Clinton, Mississippi to its confluence with the Big Black River. The impaired segment is in Hinds and Madison Counties near Flora from Tinnin Road to the confluence with Spring Creek. The impaired segment also includes parts of Limekiln Creek, which flows into Bogue Chitto Creek from the east, and Straight Fence Creek, which flows into Bogue Chitto Creek from the west, Figure 1.1. The watershed of the impaired segment includes urban areas near Jackson and Clinton, Mississippi as well as rural, agricultural areas near Flora and Pocahontas, Mississippi.

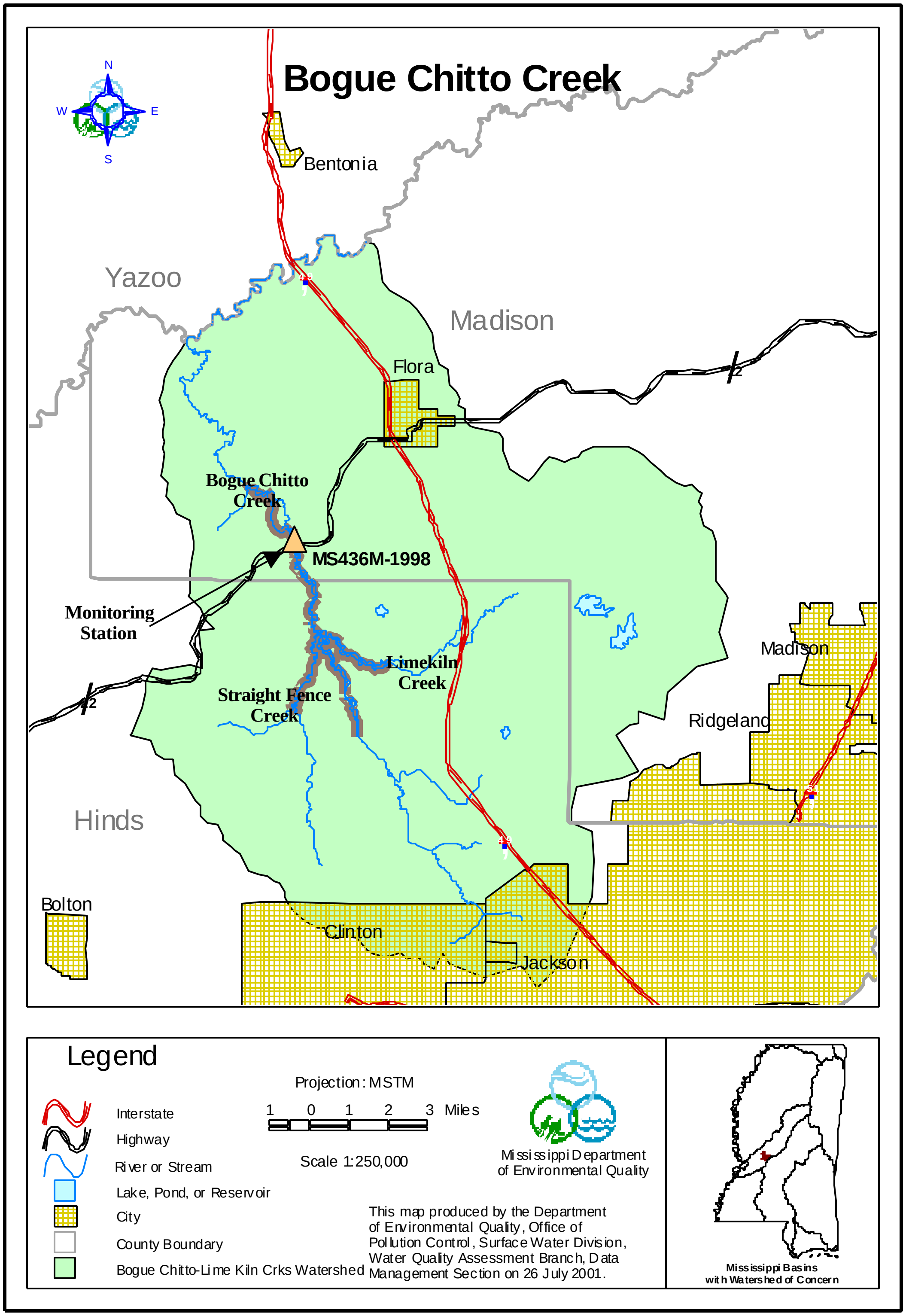

Figure 1.1. Location of 303(d) Listed Segment

1.3 Discussion of Instream Water Quality Data

The State's 1998 Section 305(b) Water Quality Assessment Report was reviewed to assess water quality conditions and data available for the watershed. Limited water quality data are available for the monitored segment of Bogue Chitto Creek and its tributaries, Limekiln and Straight Fence Creeks. According to the report, Bogue Chitto Creek is partially supporting for the use of aquatic life support. These conclusions were based on water chemistry data and screening-level biological assessment conducted as a part of the Bogue Chitto Creek Watershed Nonpoint Source Project in 1991 through 1995. This monitoring project was designed to assess the effectiveness and overall benefits of best management practices (BMPs) installed in the Bogue Chitto Creek Watershed. Water quality monitoring was conducted at one location in Bogue Chitto Creek and at the edge of the fields where the BMPs were installed both before and after BMP installation. The installed BMPs consisted of terracing and grass field boarders. Water quality data collected in Bogue Chitto Creek did not show that water quality was improved as a result of BMP installation. The screening-level biological assessments conducted both before and after BMP installation rated the creek as fair-to-poor. One reason for the lack of measurable improvement in water quality is that the BMPs were installed only on one small farm within a relatively large watershed. Edge of field monitoring, however, did show a significant decrease in suspended solids and total phosphorous concentrations in runoff from fields due to the construction of BMPs.

Additional water quality sampling and biological assessments were collected as part of a 303(d) study for Bogue Chitto Creek in August of 1999. During this study, data were collected on Bogue Chitto Creek near Flora at Highway 22. The objectives of this study were to confirm biological and water quality impairment in Bogue Chitto Creek near Flora and to identify the specific cause and sources of biological impairment. Chemical monitoring included field and laboratory analysis of surface water. In-situ water quality measurements were made using multi-parameter water quality instruments. Calibrated field instruments were utilized to measure DO, DO saturation, water temperature, specific conductivity, pH, and total dissolved solids. Instruments were continuously deployed for 24 hours during the study for diurnal measurement of these water quality parameters. A summary of in-situ data collected during the project is given in Table 1.1.

Table 1.1. In-Situ Water Quality Data for Bogue Chitto Creek @ Hwy 22

	Average	Maximum	Minimum
Water Temperature (°C)	28.52	32.91	23.04
pH	7.51	8.21	7.07
Dissolved Oxygen (mg/L)	5.20	9.09	2.04
Dissolved Oxygen Saturation (%)	68.43	110.00	25.10
Conductivity (µs/cm)	409.69	451.00	232.00
Total Dissolved Solids (mg/L)	262.00	289.00	148.00

Surface water samples were collected by manual grab sampling. Grab samples were collected three times during the study. Water chemistry parameters selected for laboratory analysis and laboratory results are given in Table 1.2. The date and times of the sample collection are also shown in the table.

Table 1.2. Water Chemistry Data for Bogue Chitto Creek @ Hwy 22

Parameter	8/25/1999 07:35	8/25/1999 14:45	8/26/1999 11:15
Sample Depth, ft	0.40	0.28	0.45
Biochemical Oxygen Demand – 5 Day (BOD_5), mg/L	2.00	2.00	2.00
Total Organic Carbon (TOC), mg/L	6.00	6.00	6.00
Chemical Oxygen Demand, mg/L	24.00	18.00	23.00
Total Phosphorus(as P), mg/L	0.28	0.44	0.26
Total Kjeldahl Nitrogen (TKN), mg/L	1.09	0.96	0.98
Ammonia Nitrogen (as N), mg/L	1.16	0.66	0.65
Nitrite + Nitrate, mg/L	0.13	0.12	0.12
Total Alkalinity (as $CaCO_3$), mg/L	125.00	124.00	132.00
Turbidity (NTU), mg/L	55.00	23.00	24.00
Chlorides, mg/L	21.70	21.50	22.30

1.4 Cause of Impairment

Bogue Chitto, Straight Fence, and Limekiln Creeks are listed on the 303(d) list for two causes, biological impairment and organic enrichment/low DO. The term biological impairment describes impairment to waterbodies in which at least one biological assemblage (fish, macroinvertabrates, or algae) indicates less than full support with moderate modification of the biological community noted. Current sampling methods allow MDEQ to make an accurate determination of whether or not the biological community in a specific waterbody is impaired. However, biological sampling often does not identify the specific pollutant or pollutants that are the cause of biological impairment.

As a result, MDEQ uses a process-of-elimination approach to identify the pollutants causing biological impairment. For the Bogue Chitto Creek watershed, all available data were analyzed, including water chemistry and in-situ data, photographs of the waterbody, and inventories of landuse and point source dischargers. Analysis of these data eliminated causes such as erosion and sedimentation because evidence of stream bank erosion was not visible and water chemistry did not show elevated levels of turbidity or dissolved solids. Because neither significant levels of nitrogen and phosphorous species nor an overabundance of algae were found in the waterbody, nutrients were eliminated as a direct cause of impairment. Also, levels of ammonia nitrogen in the waterbody were not above standards for ammonia toxicity. Measurements of pH, alkalinity, and hardness were all within the expected range for waterbodies in Mississippi. However, measurements of DO collected during the field study in 1999 showed that DO levels in Bogue Chitto Creek were below the levels required in Mississippi's Water Quality Standards. In addition, diurnal variations in the creek's DO levels ranged from 2.04 mg/L to 9.09 mg/L, indicating that the levels of organic material in the creek were elevated.

This evidence indicates the biological impairment found in Bogue Chitto Creek is due to elevated amounts of organic material in the creek which result in decreased DO levels. Subsequently, this TMDL was developed for Bogue Chitto Creek for organic enrichment/low DO. This TMDL addresses both causes given on the 303(d) List, organic enrichment/low DO and biological impairment, for Bogue Chitto, Straight Fence, and Limekiln Creeks.

2.0 TMDL ENDPOINT

2.1 Segment Use and Applicable State Standards

Designated beneficial uses and water quality standards are established by the *State of Mississippi Water Quality Criteria for Intrastate, Interstate, and Coastal Waters* regulations. The designated use for Bogue Chitto, Limekiln, and Straight Fence Creeks as defined by the regulations is Fish and Wildlife Support. Waters designated for use as Fish and Wildlife support must also be suitable for secondary contact, which is defined as incidental contact with the water. The water quality standard applicable to the use of the waterbody and the pollutant of concern is defined in the *State of Mississippi Water Quality Criteria for Intrastate, Interstate, and Coastal Waters*. The applicable standard specifies that the DO concentrations shall be maintained at a daily average of not less than 5.0 mg/L with an instantaneous minimum of not less than 4.0 mg/L.

2.2 Selection of TMDL Endpoint and Critical Conditions

One of the major components of a TMDL is the establishment of instream numeric endpoints, which are used to evaluate the attainment of acceptable water quality. Instream numeric endpoints, therefore, represent the water quality goals that are to be achieved by meeting the load and wasteload allocations specified in the TMDL. The endpoints allow for a comparison between observed instream conditions and conditions that are expected to restore designated uses The instream DO target for this TMDL is a daily average of not less than 5.0 mg/L. The instantaneous minimum portion of the DO standard was considered when establishing the instream target for this TMDL. However, it was determined that using the daily average standard with the conservative modeling assumptions would be sufficiently protective of the instantaneous minimum standard. More data will be collected during the development of the Phase II TMDL, which will allow a more thorough evaluation of both the daily average and instantaneous minimum portions of the DO standard.

Low DO typically occurs during seasonal low-flow periods of late summer and early fall. Elevated oxygen demand is of primary concern during low-flow periods because the effects of minimum dilution and high temperatures combine to produce the worst case potential effect on water quality (USEPA, 1997). The low-flow, high-temperature period is referred to as the critical condition. The maximum impact of oxidation of organic material is generally not at the location of the point source discharge, but at some distance downstream, where the maximum DO deficit occurs. The DO deficit is defined as the difference between the DO concentration at 100% saturation and the actual DO. The point of maximum DO deficit, also called the DO sag, will be use to define the endpoint required for this TMDL. The TMDL will be based on a daily average of not less than 5.0 mg/L DO at the DO sag during critical conditions in Bogue Chitto Creek.

3.0 Source Assessment

This Phase I TMDL Report includes the identification of all known potential pollutant sources in the Bogue Chitto Creek Watershed and an analysis of available water quality data. The source assessment was used as the basis of development for the model and analysis of the TMDL allocation. The potential point and nonpoint pollutant sources were characterized by the best available information, monitoring data, and literature values. This section documents all available information.

3.1 Assessment of Point Sources

Photo 3.1. Outfall for Baptist Children's Village

The first step in assessing pollutant sources in the Bogue Chitto Creek watershed was locating the National Pollutant Discharge Elimination System (NPDES) permitted sources. There are nine such sources permitted to discharge treated wastewater into Bogue Chitto Creek or its tributaries, Table 3.1. These wastewater treatment facilities serve a variety of uses within the watershed including residential areas, childcare facilities, and restaurants. The effluent from each facility was characterized based on all available data including information on each facility's wastewater treatment system, permit limits, and discharge monitoring reports.

Table 3.1. NPDES Permitted Facilities

Name	NPDES Permit	Treatment Type	Receiving Waterbody
Baptist Children's Village	MS0021849	Conventional Lagoon	An Unnamed Tributary of Bogue Chitto Creek
Catfish Haven Restaurant	MS0044644	Aerated Lagoon	Limekiln Creek
City of Clinton – Briars POTW	MS0047619	Activated Sludge	An Unnamed Tributary of Bogue Chitto Creek
City of Clinton – Lovett POTW	MS0023230	Activated Sludge	An Unnamed Tributary of Straight Fence Creek
City of Clinton – Northeast POTW	MS0021164	Activated Sludge	Straight Fence Creek
Southern Oaks Subdivision	MS0046647	Aerated Lagoon	An Unnamed Tributary of Bogue Chitto Creek
Lake Cavalier Subdivision	MS0031232	Activated Sludge	An Unnamed Tributary of Limekiln Creek
Jackson POTW (Presidential Hills Subdivision)	MS0030295	Aerated Lagoon	Bogue Chitto Creek
Lake Lorman Utility District	MS0043401	Conventional Lagoon with Wetlands	An Unnamed Tributary of Limekiln Creek

During the assessment, each of these facilities, with the exception of the Jackson POTW, was inspected. The purpose of the inspections was to ensure that each of the facilities was operating in compliance with its permit limits and was being maintained properly. During the inspections photographs of the discharge points were taken and their latitude and longitude were recorded. The method used to treat the wastewater at each facility was also noted. The inspections showed that the majority of the facilities were well operated. However, problems with maintenance were noted at some of the facilities. The environmental permitting compliance division at MDEQ will ensure that maintenance problems are corrected. The point source assessment also included an evaluation of the discharge monitoring data available for each facility. Discharge monitoring data are vital to characterizing effluent from each facility.

During the inspections MDEQ was informed that plans are in progress to close the Lake Cavalier Facility, and treat this wastewater at the Lake Lorman Facility. Final plans for closure of the Lake Cavalier Facility are being developed which will allow the facility to be closed by the end of December 2001. Because of this expected change, the Lake Cavalier Facility was omitted from the TMDL model and the waste load allocations developed with this TMDL.

3.2 Assessment of Nonpoint Sources

Photo 3.2. Potential Nonpoint Sources

Nonpoint loading of $TBOD_U$ in a waterbody results from the transport of the pollutants into receiving waters by overland surface runoff and groundwater infiltration. Landuse activities within the drainage basin, such as agriculture, silvaculture, and urbanization contribute to nonpoint source loading. Other nonpoint pollution sources include atmospheric deposition and natural weathering of rocks and soil.

The 103,833 acre drainage area of Bogue Chitto Creek contains many different landuse types, including urban, forest, cropland, pasture, water, and wetlands. The most current landuse information available for the watershed is based on data collected by the State of Mississippi's Automated Resource Information System (MARIS). This data set is based on Landsat Thematic Mapper digital images taken between 1992 and 1993. The landuse within the Bogue Chitto Creek watershed is shown in Table 3.2 and Figure 3.1.

As shown in the figure, the dominant landuse in the watershed is agriculture. Agricultural activities are likely to be a significant source of organic material in the watershed, however they do not account for a significant portion of this Phase I TMDL. This is because the Phase I TMDL was calculated for low-flow conditions, when runoff from nonpoint source contributors such as agricultural areas is minimal. Urban development is another important portion of the nonpoint source contribution. There has been rapid growth in Madison County since the MARIS landuse data were collected in 1992 and 1993. Many new residential subdivisions have been built in the area. Some of these subdivisions use septic tanks or individual, onsite wastewater treatment systems instead of connections to municipal treatment systems. Effluent from these systems is another potential contributor. Runoff from residential lawns as well as several golf courses which are located within the watershed may be an additional nonpoint source of organic material. Because the TMDL was calculated for low-flow conditions, contributions from urban areas are likely under represented in this Phase I TMDL. Plans, however, are being developed to update the landuse information available for the Bogue Chitto Creek watershed. The updated landuse would provide detailed information about the locations of agricultural areas as well as residential development. It will also provide information useful for quantifying pollution loads from these sources. This updated landuse information and nonpoint source assessment will be used to develop the Phase II TMDL.

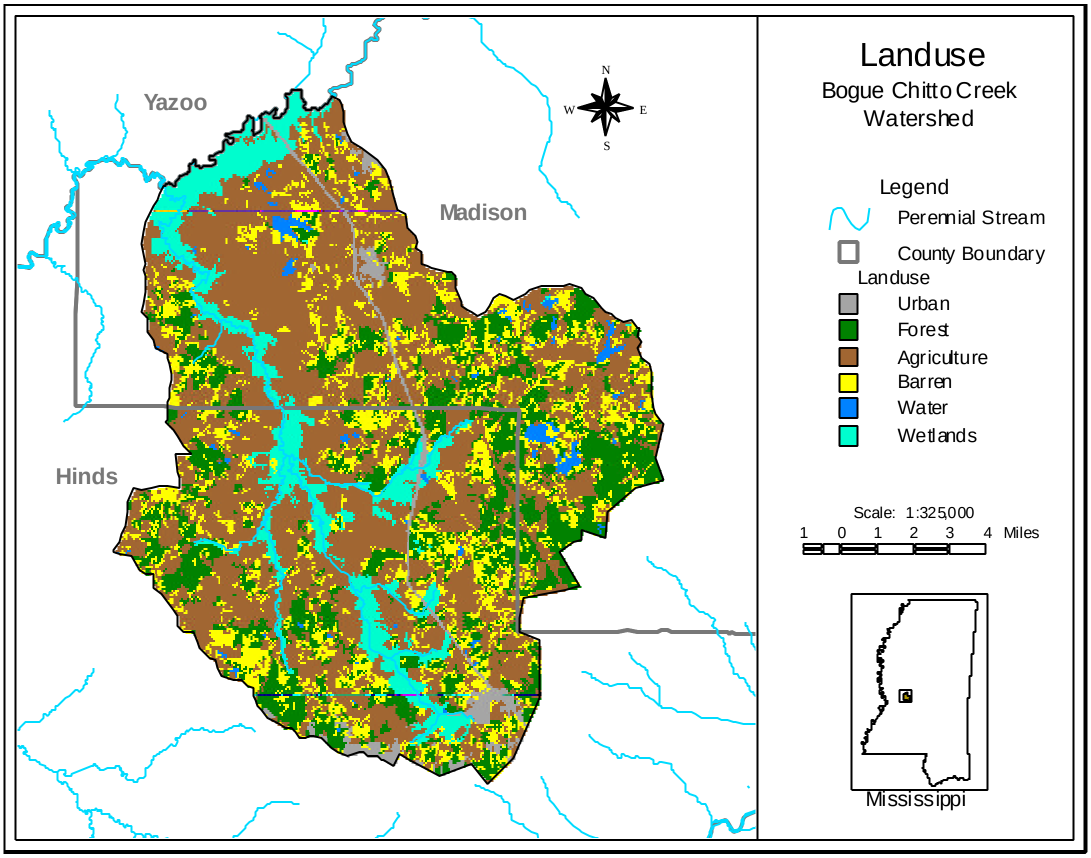

Figure 3.1. Landuse Distribution

Table 3.2. Landuse Distribution

Urban	Forest	Agriculture	Barren	Water	Wetlands	Total
2,352	33,786	54,611	647	2,482	9,955	103,833
2%	32%	53%	1%	2%	10%	100%

4.0 Modeling Procedure: Linking the Sources to the Endpoint

Establishing the relationship between the instream water quality target and the source loading is a critical component of TMDL development. It allows for the evaluation of management options that will achieve the desired source load reductions. The link can be established through a range of techniques, from qualitative assumptions based on sound scientific principles to sophisticated modeling techniques. Ideally, the linkage will be supported by monitoring data that allow the TMDL developer to associate certain waterbody responses to flow and loading conditions. In this section, the selection of the modeling tools, setup, and model application are discussed.

4.1 Modeling Framework Selection

A mathematical model, named AWFWUL1, for DO distribution in freshwater streams was used for developing the TMDL. The use of AWFWUL1 is promulgated in the *Wastewater Regulations for National Pollutant Discharge Elimination System (NPDES) Permits, Underground Injection Control (UIC) Permits, State Permits, Water Quality Based Effluent Limitations and Water Quality Certification* (MDEQ, 1994). This model has been approved by EPA and has been used extensively at MDEQ. A key reason for using the AWFWUL1 model in TMDL development is its ability to assess instream water quality conditions in response to point and nonpoint source loadings.

The model is a steady-state, daily average computer model that utilizes a modified Streeter-Phelps DO sag equation. Instream processes simulated by the model include $CBOD_U$ decay, nitrification, and reaeration. The model is also capable of simulating sediment oxygen demand and respiration and photosynthesis of algae. These processes, however, were not included in the Bogue Chitto Creek model. Figure 4.1 shows how these processes are related in a typical DO model. Reaction rates for the instream processes are input by the user and corrected for temperature by the model. The model output includes water quality conditions in each computational element for DO, $CBOD_U$, and NH_3-N concentrations. The hydrological processes simulated by the model include stream velocity and flow from point sources and spatially distributed inputs.

The model was set up to calculate reaeration within each reach using the Tsivoglou formulation, which is recommended for small streams with flow less than 10 cfs. The Tsivoglou formulation calculates reaeration (Ka) within each reach according to Equation 4.1.

$$\boxed{\mathbf{Ka = CSU}} \qquad \text{(Equation 4.1)}$$

Were S is the slope in ft/mile, U is the reach velocity in mile/day, and C is the escape coefficient, which is 0.11 for streams with flow less than 10 cfs.

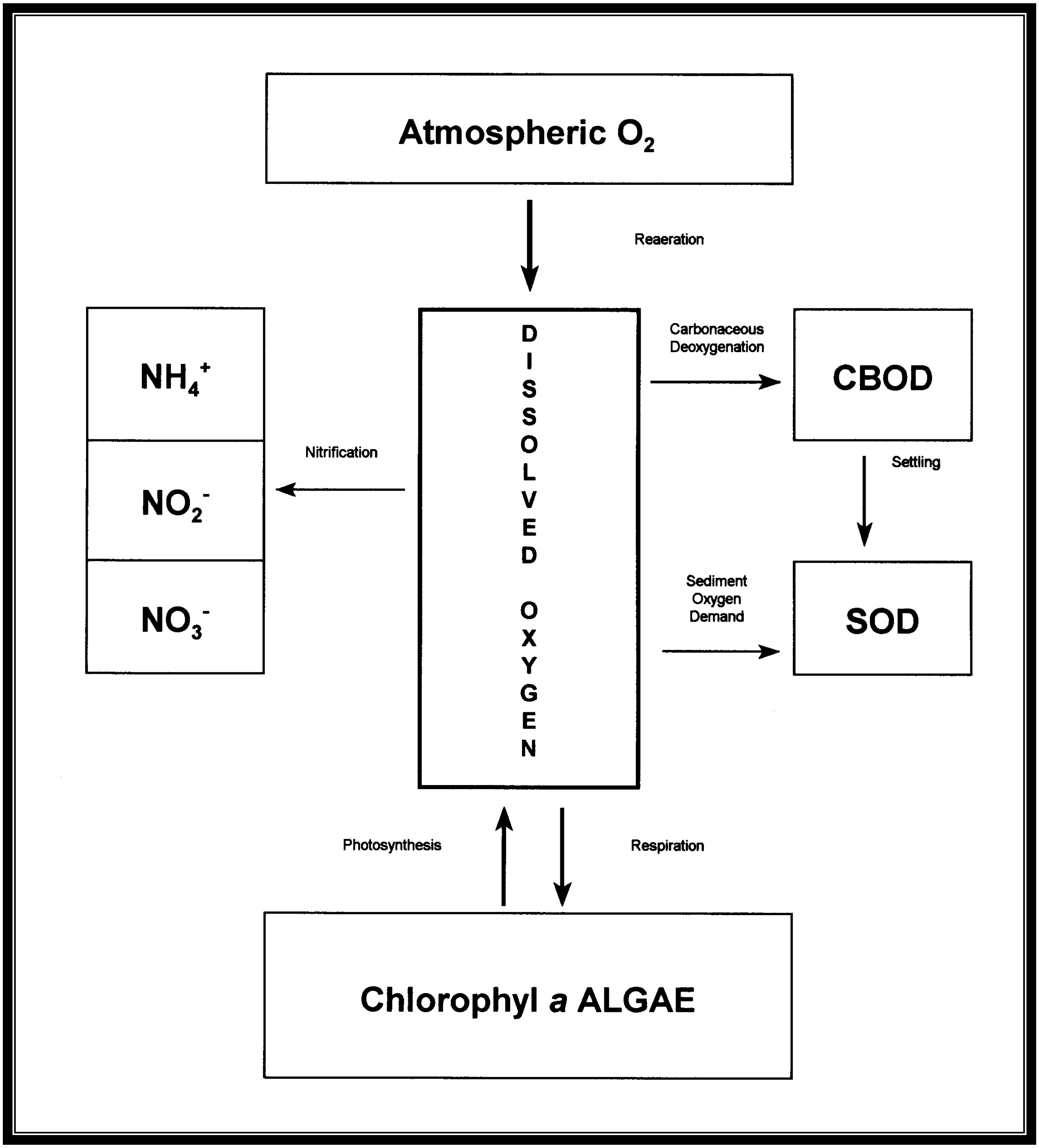

Figure 4.1. Instream Processes in a Typical DO Model

4.2 Model Setup

The Bogue Chitto Creek TMDL model includes the 303(d) listed portions of Bogue Chitto, Limekiln, and Straight Fence Creeks as well as all the drainage areas that are upstream of the segment. The modeled waterbodies were divided into reaches for input into the AWFWUL1 model. Reach divisions were made at any major change in the hydrology of the waterbody, such as a significant change in slope or the confluence of a tributary or point source discharge. The watershed was modeled according to the diagram shown in Figure 4.2. The slope of each reach was estimated from USGS quad maps and input into the model in units of feet/mile. Within each reach, the modeled segments were divided into computational elements of 0.1 mile. The hydrological and water quality characteristics are calculated and output by the model for each computational element.

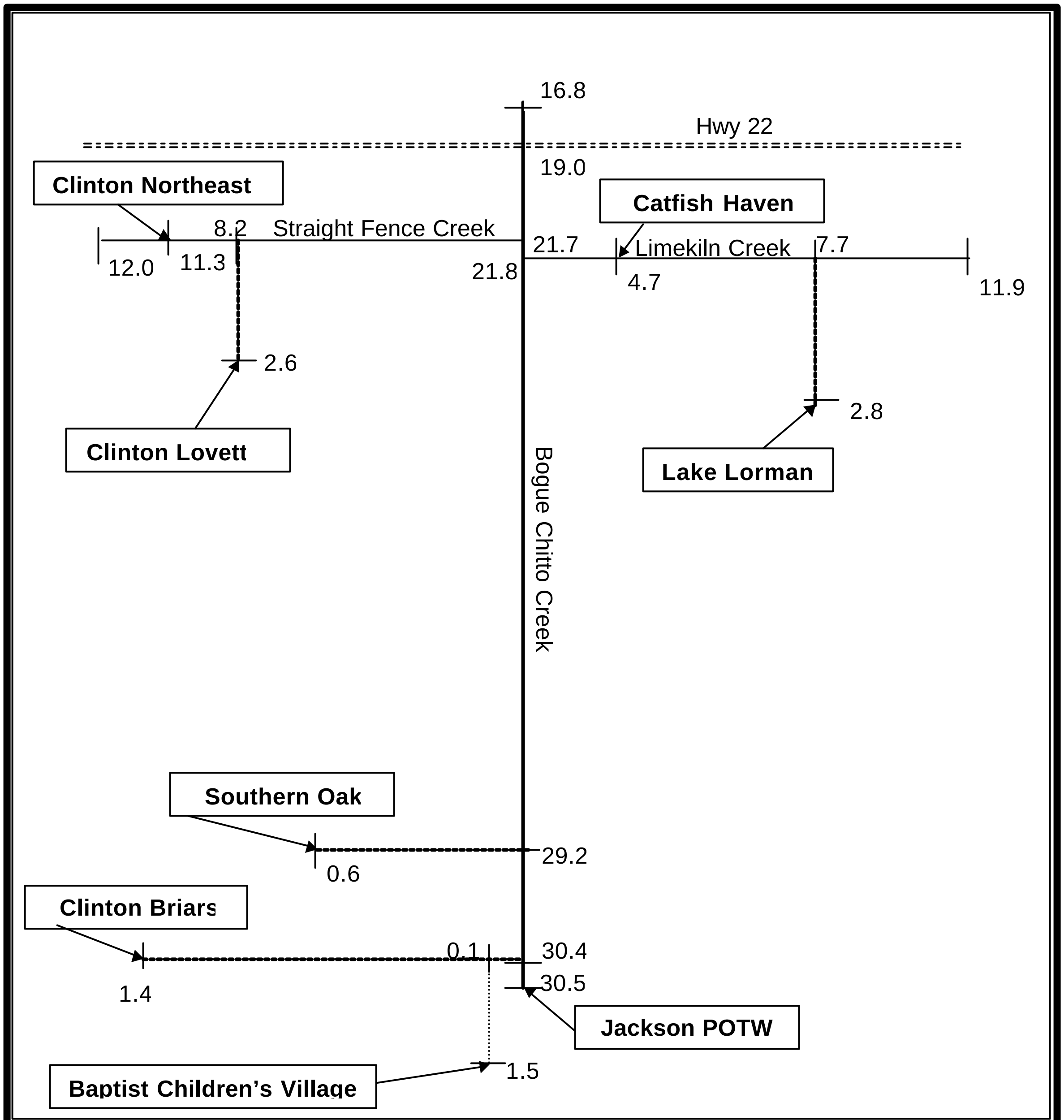

Figure 4.2. Bogue Chitto Creek Model Setup (Note: Figure not to Scale)

As shown in Figure 4.2, the eight NPDES permitted point sources discharge into Bogue Chitto, Limekiln, and Straight Fence Creeks or unnamed tributaries of these creeks. The unnamed tributaries are shown as dashed lines in the figure. The numbers on the figure represent river miles at which point sources discharges or confluences of the creeks are located. River miles are assigned to waterbodies, beginning with zero at the mouth.

4.3 Source Representation

Both point and nonpoint sources were represented in the model. The loads from NPDES permitted sources were added as a direct input into the appropriate reach of the waterbody as a flow in cfs and a load of $CBOD_U$ and ammonia nitrogen in lbs/day. Loads for nonpoint sources were input into the model as a spatially distributed input. Spatially distributed loads, which represent nonpoint sources of flow, $CBOD_U$, and ammonia nitrogen were distributed evenly into each computational element of Bogue Chitto, Straight Fence, and Limekiln Creeks.

Organic material discharged to a stream from an NPDES permitted point source is typically quantified as 5-day biochemical oxygen demand (BOD_5). BOD_5 is a measure of the oxidation of carbonaceous and nitrogenous material over a 5-day incubation period. However, oxidation of nitrogenous material, called nitrification, usually does not take place within the 5-day period because the bacteria that are responsible for nitrification are normally not present in large numbers and have slow reproduction rates (Metcalf and Eddy, 1991). Thus, BOD_5 is generally considered equal to $CBOD_5$. Because permits for point source facilities are written in terms of BOD_5 while predictive models used for TMDL development are typically developed using $CBOD_U$, a ratio between the two terms is needed, Equation 4.2. The literature values of the $CBOD_U$ to $CBOD_5$ ratio are given in *Empirical Stream Model Assumptions for Conventional Pollutants and Conventional Water Quality Models* (MDEQ, 1995). The value of the ratio depends on the treatment type used in the wastewater treatment facility. A ratio of 2.3 was used for advanced treatment, while a ratio of 1.5 was used for mechanical secondary treatment. These values are recommended for use by MDEQ regulations when actual field data is not available.

$$\boxed{\mathbf{CBOD_U = CBOD_5 * Ratio}} \qquad \text{(Equation 4.2)}$$

In order to convert the ammonia nitrogen (NH_3-N) loads to an oxygen demand, a factor of 4.57 pounds of oxygen per pound of ammonia nitrogen (NH_3-N) oxidized to nitrate (NO_3) was used. Using this factor is a conservative modeling assumption because it assumes that all of the ammonia is converted to nitrate through nitrification, which is not necessarily accurate. The oxygen demand caused by nitrification of ammonia is equal to the $NBOD_U$ load. The sum of $CBOD_U$ and $NBOD_U$ is equal to the point source load of $TBOD_U$. The loads of $TBOD_U$ from each of the existing point sources for summer and winter conditions are given in Table 4.1 and Table 4.2. The loads were based on the maximum allowable loads according to NPDES permits, another conservative assumption.

Table 4.1. Point Source Loads, Summer Conditions

Facility	Flow (cfs)	$CBOD_5$ (mg/L)	$CBOD_5$/ $CBOD_U$ Ratio	$CBOD_U$ (lbs/day)	NH_3-N (mg/L)	$NBOD_U$ (lbs/day)	$TBOD_U$ (lbs/day)
Baptist Children's Village	0.093	30	1.5	22.5	2.0	4.6	27.1
Catfish Haven Restaurant	0.004	45	1.5	1.6	2.0	0.2	1.8
City of Clinton – Briars POTW	0.975	10	2.3	120.9	2.0	48.0	168.9
City of Clinton – Northeast POTW	0.464	10	2.3	57.6	2.0	22.9	80.4
City of Clinton – Lovett POTW	0.427	15	2.3	79.4	2.0	21.0	100.5
Jackson POTW (Triangle Water Co - Pres. Hill)	1.160	10	1.5	93.8	2.0	57.2	151.0
Lake Lorman Utility District	0.099	10	1.5	8.0	2.0	4.9	12.9
Southern Oaks Subdivision	0.062	30	1.5	15.0	2.0	3.1	18.1
Total for All Facilities				**398.7**		**161.8**	**560.6**

Table 4.2. Point Source Loads, Winter Conditions

Facility	Flow (cfs)	$CBOD_5$ (mg/L)	$CBOD_5$/ $CBOD_U$ Ratio	$CBOD_U$ (lbs/day)	NH_3-N (mg/L)	$NBOD_U$ (lbs/day)	$TBOD_U$ (lbs/day)
Baptist Children's Village	0.093	30	1.5	22.5	2.0	4.6	27.1
Catfish Haven Restaurant	0.004	45	1.5	1.6	2.0	0.2	1.8
City of Clinton – Briars POTW	0.975	10	2.3	120.9	2.0	48.0	168.9
City of Clinton – Northeast POTW	0.464	10	2.3	57.6	2.0	22.9	80.4
City of Clinton – Lovett POTW	0.427	15	2.3	79.4	2.0	21.0	100.5
Jackson POTW (Triangle Water Co - Pres. Hill)	1.160	10	1.5	93.8	2.0	57.2	151.0
Lake Lorman Utility District	0.099	14	1.5	11.2	2.0	4.9	16.1
Southern Oaks Subdivision	0.062	30	1.5	15.0	2.0	3.1	18.1
Total for All Facilities				**402.0**		**161.8**	**563.8**

Direct measurements of nonpoint source loads of $CBOD_U$ and NH_3-N were not available for the Bogue Chitto Creek Watershed. The background contributions of $CBOD_U$ and total ammonia as nitrogen (NH_3–N) were estimated based on *Empirical Stream Model Assumptions for Conventional Pollutants and Conventional Water Quality Models* (MDEQ, 1994). According to these regulations, the background concentrations are $CBOD_5$ = 1.33 mg/L and NH_3-N = 0.1 mg/L.

4.4 Selection of Representative Modeling Periods

In order to account for seasonal variations in stream temperature and the stream temperature's effect on the $CBOD_U$ decay rate and dissolved oxygen saturation, the model was run for both summer and winter temperature conditions. The temperatures used in the model are 26°C in the summer (May through October) and 20°C in the winter (November through April). The headwater instream DO was assumed to be 85% of saturation at the stream temperature. The instream $CBOD_U$ decay rate is dependent on temperature, according to Equation 4.3.

$$\boxed{\mathbf{Kd_{(T)} = Kd_{(20°C)}(1.047)^{T-20}}} \qquad \text{(Equation 4.3)}$$

Where Kd is the $CBOD_U$ decay rate and T is the assumed instream temperature. The assumptions regarding the instream temperatures, background DO saturation, and $CBOD_U$ decay rate are required by the *Empirical Stream Model Assumptions for Conventional Pollutants and Conventional Water Quality Models* (MDEQ, 1994). The temperatures, $CBOD_U$ decay rates, and DO saturation values used in the model are given in Table 4.3.

Table 4.3 Seasonal Model Inputs

Season	Temperature (°C)	$CBOD_U$ Decay Rate (Day^{-1})	85% DO Saturation (mg/l)
Summer (May – Oct)	26	0.39	6.9
Winter (Nov – April)	20	0.30	7.7

4.5 Model Calibration Process

Due to the lack of water quality monitoring data in the headwater reaches of the modeled creeks, the water quality component of the model was not calibrated. Instead, the model inputs were based on assumptions found in *Empirical Stream Model Assumptions for Conventional Pollutants and Conventional Water Quality Models* (MDEQ, 1994). The hydrological portion of the model was calibrated to simulate low-flow, critical conditions. USGS flow data, which was collected on Bogue Chitto Creek near Flora, was used to determine the 7Q10 flow coefficient for the Bogue Chitto Creek Watershed. 7Q10 flow is the lowest 7-day average flow expected to occur within a 10-year time period. The 7Q10 flow coefficient (7Q10 value in cfs/drainage area in square miles) was used to estimate the amount of water draining into the Bogue Chitto Creek and its tributaries during low-flow conditions. According to *Techniques for Estimating 7-Day, 10-Year Low Flow Characteristics for Ungaged Sites on Streams in Mississippi*, the 7Q10 flow coefficient for the Bogue Chitto Creek Watershed is 0.01 cfs/square mile of drainage area.

4.6 Model Results

Once the model setup was complete, the model was used to predict water quality conditions in Bogue Chitto Creek and its tributaries. The model was first run under baseline conditions. Under baseline conditions, all of the loads from NPDES permitted point sources were set at their maximum permit limits, Table 4.1. Thus, baseline model runs reflect the current condition of Bogue Chitto Creek without any reduction of $TBOD_U$ loads. The model was then run using a trial-and-error process to determine the maximum $TBOD_U$ loads from the point source facilities which would not violate water quality standards for DO. These model runs are called load reduction scenarios.

4.6.1 Baseline Model Runs

Figures 4.3 through 4.6 show the AWFWUL1 model results from the baseline model runs. The baseline model runs were setup to simulate summer temperature conditions only, since the summer temperatures represent critical conditions when the dissolved oxygen saturation is lower and the $CBOD_U$ decay rates are greater. The figures show the modeled daily average DO in Bogue Chitto, Limekiln, and Straight Fence Creeks. The dashed line on each figure represents the DO standard of 5.0 mg/L. Figure 4.3 shows the daily average instream DO concentrations in Bogue Chitto Creek, beginning with river mile 30.5 and ending with river mile 16.8. The DO sag, or maximum DO deficit, occurs in Bogue Chitto Creek below the discharges from the Jackson POTW, Baptist Children's Village, Clinton Briars, and Southern Oaks Subdivision, at river mile 28.0.

Figure 4.4 shows the daily average DO in Limekiln Creek, beginning with river mile 11.9 and ending with river mile 0.0, at the confluence of Limekiln Creek with Bogue Chitto Creek. The data show that the DO standard is not violated in this reach as a result of the effluent from Lake Lorman and Catfish Haven Restaurant. Figure 4.5 shows the daily average DO in Straight Fence Creek, beginning with river mile 12.0 and ending at river mile 0.0, at the confluence of Straight Fence Creek with Bogue Chitto Creek. The model shows that there are two DO sags in this reach, due to the effluent from Clinton Northeast, at river mile 10.3, and Clinton Lovett, at river mile 7.4. Figure 4.6 shows the predicted DO concentration in an Unnamed Tributary of Bogue Chitto Creek, beginning at river mile 0.6 and ending at river mile 0.0. The effluent from the Southern Oaks Subdivision POTW is discharged into this tributary at river mile 0.6. The Unnamed Tributary flows into Bogue Chitto Creek at river mile 29.9 of Bogue Chitto Creek. As shown, the model predicted that the DO in this tributary goes to zero as a result of the point source load.

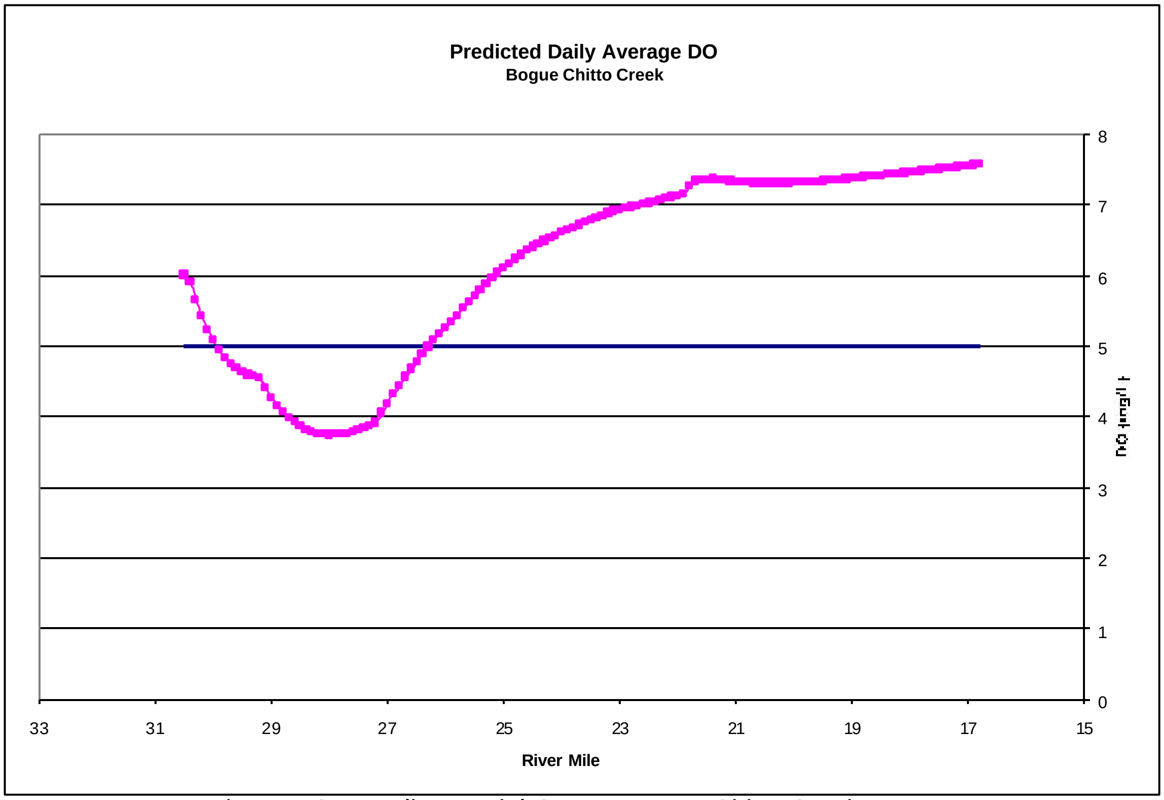

Figure 4.3. Baseline Model Output, Bogue Chitto Creek

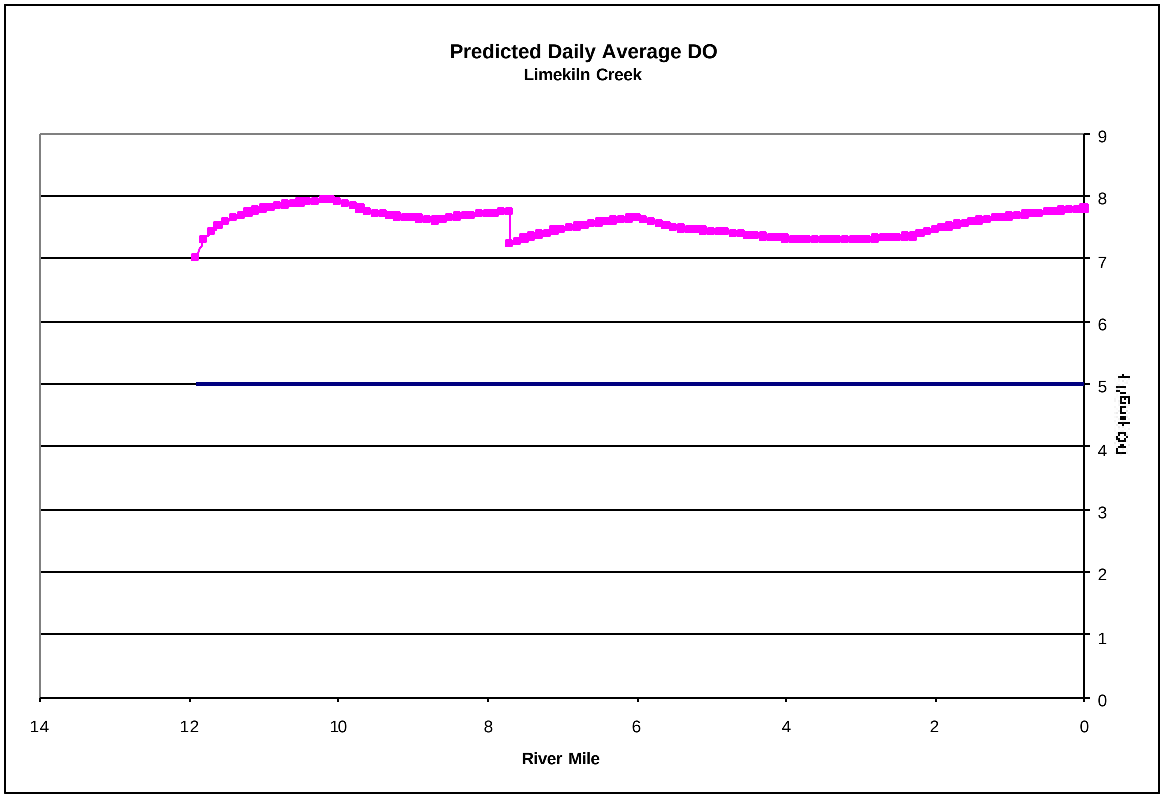

Figure 4.4. Baseline Model Output, Limekiln Creek

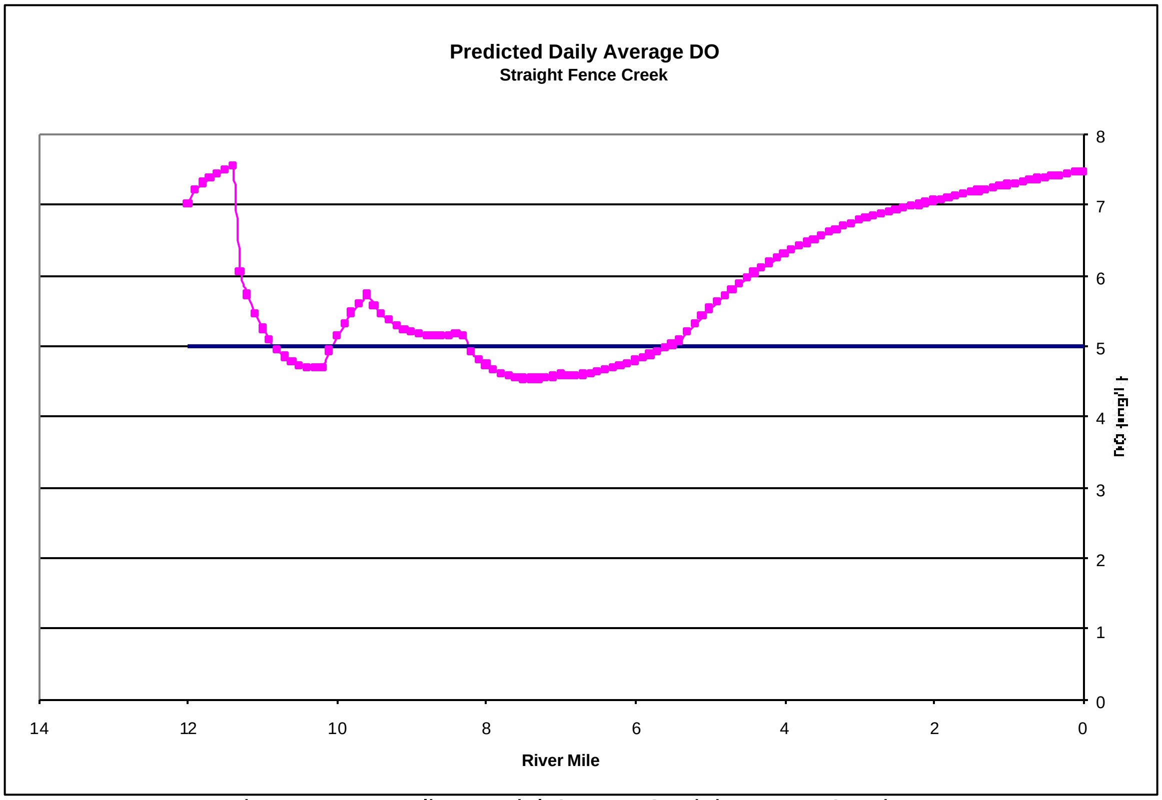

Figure 4.5. Baseline Model Output, Straight Fence Creek

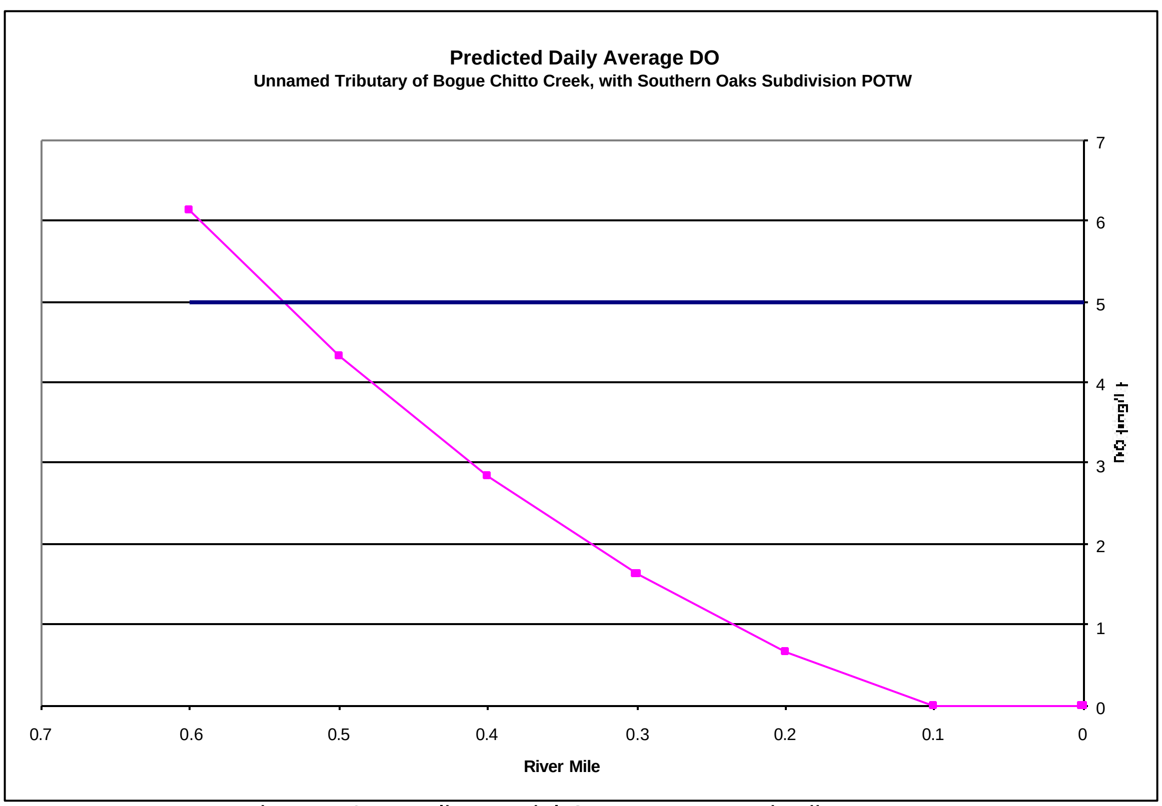

Figure 4.6. Baseline Model Output, Unnamed Tributary

4.6.2 Load Reduction Scenarios

The graphs of baseline model output show that the predicted DO falls below the DO standard in Bogue Chitto Creek, Straight Fence Creek, and one of the Unnamed Tributaries to Bogue Chitto Creek during critical conditions. As a result, reductions from the baseline loads of $TBOD_U$ are necessary in order to maintain a daily average DO of at least 5.0 mg/L. Figures 4.7 through 4.11 show model results from the load reduction scenario model runs. The load reduction scenarios were developed for both summer and winter conditions. This is because the assimilative capacity of a waterbody is generally greater in the winter season, when temperatures are lower and DO saturation of the water is greater. The load reduction scenarios involved running the model for each season using a trial-and-error process. The minimum load reductions, that allowed the maintenance of water quality standards, were selected.

The selected load reduction scenarios were used to develop the seasonal waste load allocations proposed in this TMDL. However, it is important to note that the load reduction scenarios are only one example of how the necessary reductions could be split among the permitted dischargers. The percent reduction proposed for each facility depended on the location of the discharge point as well as the size and relative contribution to the total load. As a general rule, equal percent reductions were proposed for facilities of similar size that were located close together. As an example, the Clinton Briars POTW and the Jackson POTW, which are both located in the upstream reach of Bogue Chitto Creek, were both reduced by approximately 33% during summer conditions. Other reduction scenarios could be developed to suit the specific concerns of individual dischargers, as long as the model showed that the scenario allowed attainment of water quality concerns in the receiving waterbodies.

Figure 4.7 shows the daily average instream DO concentrations in Bogue Chitto Creek after application of the selected load reduction scenario for the summer condition. The lowest DO concentration in the creek, approximately 5.0 mg/L occurs at river mile 28.0. Figure 4.8 shows the daily average DO in concentrations in Straight Fence Creek during summer conditions. Much like the figure shown for baseline conditions, there are two DO sags, the first at river mile 10.3 and the second at river mile 7.4. The DO concentration at both of these sags is approximately 5.0 mg/L. Figure 4.9 shows the daily average DO concentrations in the Unnamed Tributary of Bogue Chitto Creek during summer conditions. As shown in the Figure, the DO sag, of approximately 5.0 mg/L, occurs in the tributary at its confluence with Bogue Chitto Creek. The $TBOD_U$ loads from each of the point source facilities included in the load reduction scenario for summer conditions are given in Table 4.4. The percent reduction for each facility is based on a reduction from the current point source $TBOD_U$ loads given in Table 4.1. A total of 27.2% reduction is given for the entire watershed.

Table 4.4. Load Reduction Scenario, Summer Conditions

Facility	Flow (cfs)	$CBOD_5$ (mg/L)	$CBOD_5$/ $CBOD_U$ Ratio	$CBOD_U$ (lbs/day)	NH_3-N (mg/L)	$NBOD_U$ (lbs/day)	$TBOD_U$ (lbs/day)	Percent Reduction
Baptist Children's Village	0.093	15	1.5	11.3	2.0	4.6	15.8	41.6
Catfish Haven Restaurant	0.004	45	1.5	1.6	2.0	0.2	1.8	0.0
City of Clinton – Briars POTW	0.975	7	2.3	78.6	1.5	36.0	114.6	32.2
City of Clinton – Northeast POTW	0.464	8	2.3	43.2	2.0	22.9	66.0	17.9
City of Clinton – Lovett POTW	0.427	13	2.3	66.2	2.0	21.0	87.2	13.2
Jackson POTW (Triangle Water Co - Pres. Hill)	1.160	6	1.5	56.3	1.5	42.9	99.2	34.3
Lake Lorman Utility District	0.099	10	1.5	8.0	2.0	4.9	12.9	0.0
Southern Oaks Subdivision	0.011	15	1.5	7.5	2.0	3.1	10.6	41.6
Total for All Facilities				**272.5**		**135.5**	**408.0**	**27.2**

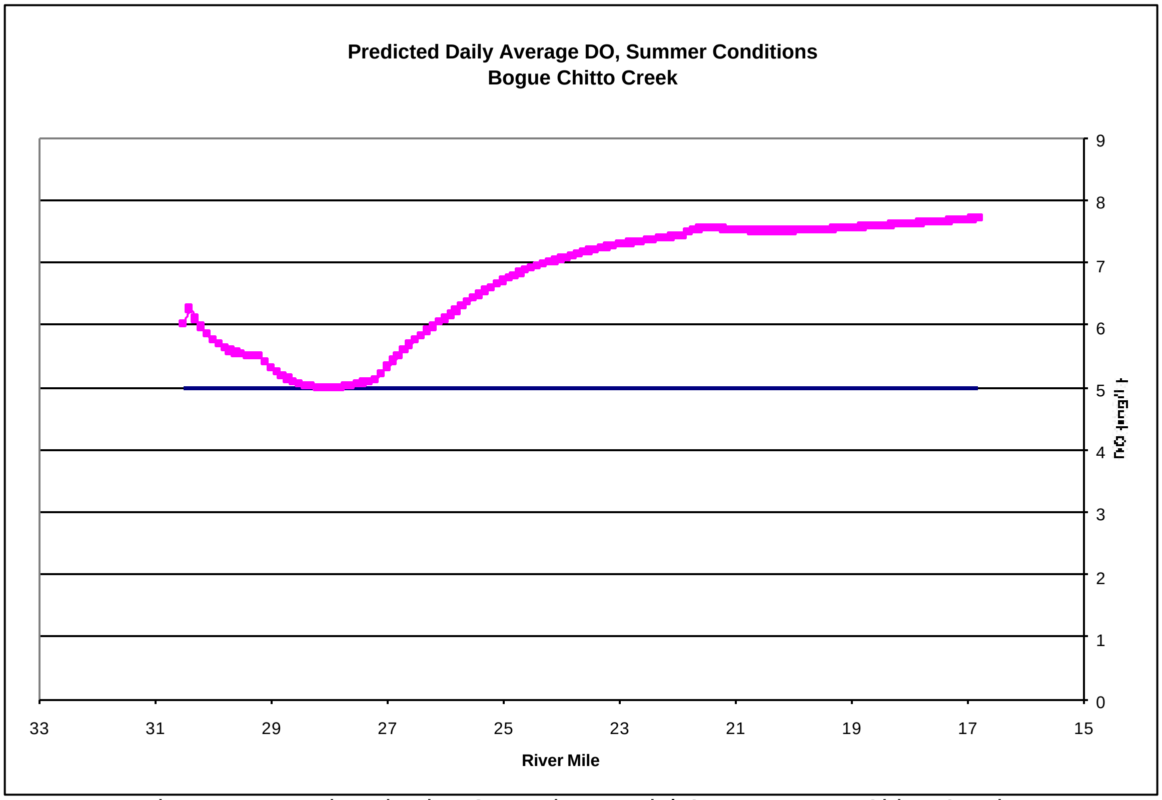

Figure 4.7. Load Reduction Scenario – Model Output, Bogue Chitto Creek

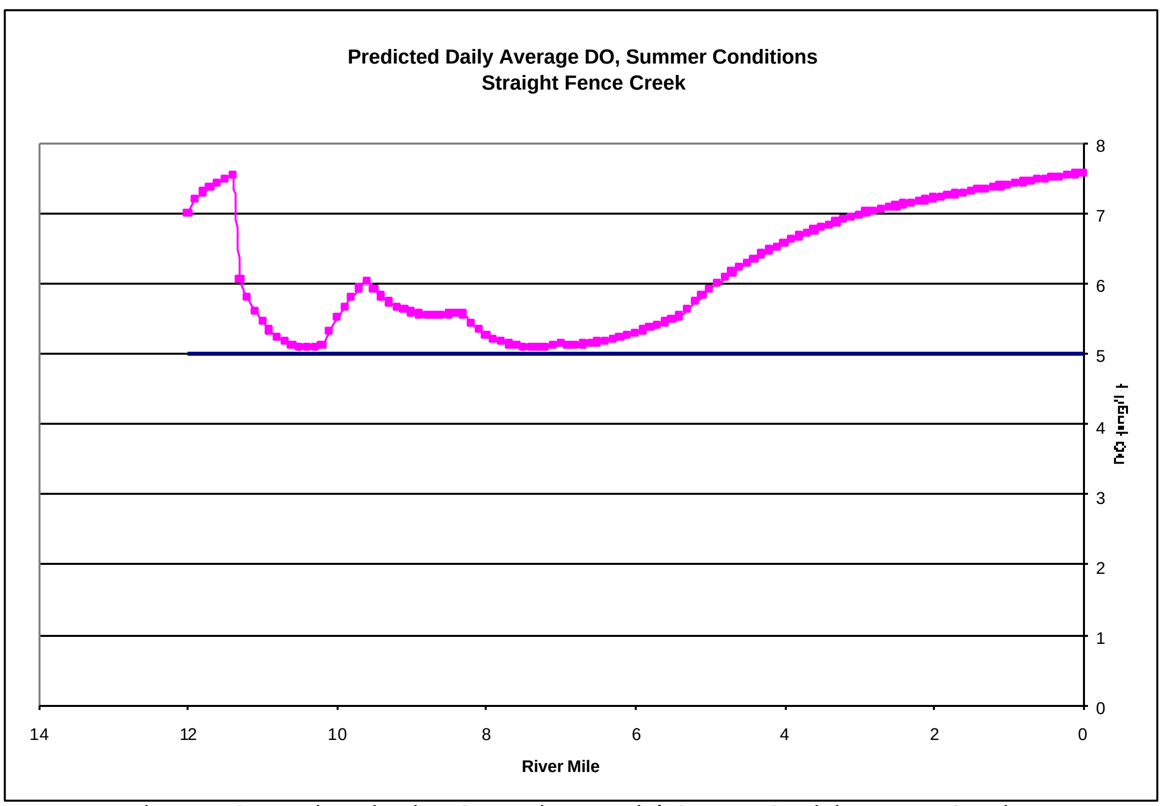

Figure 4.8. Load Reduction Scenario – Model Output, Straight Fence Creek

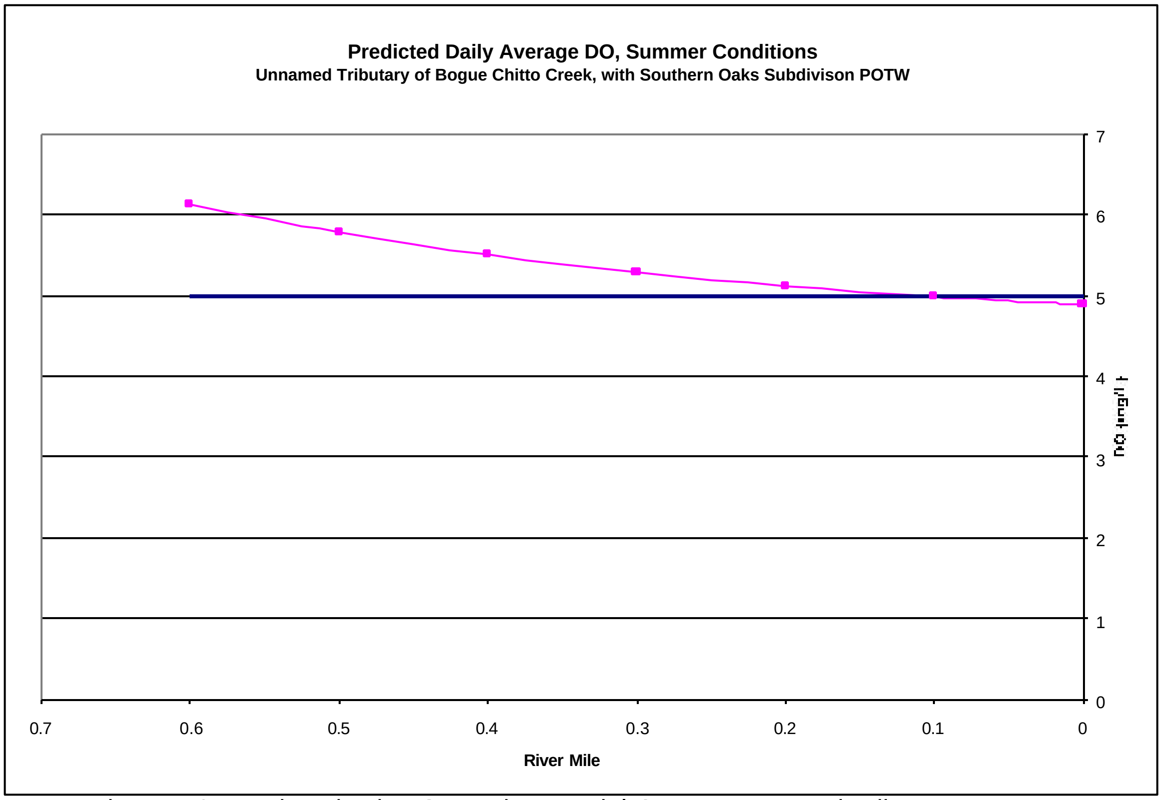

Figure 4.9. Load Reduction Scenario – Model Output, Unnamed Tributary

The load reductions necessary during the winter season are less than those needed during the summer season in order to meet water quality standards for DO. The loads from two point source facilities that discharge near the headwaters of Bogue Chitto Creek, Clinton Briars Biolac and Jackson POTW, along with the load from Southern Oaks Subdivision, were reduced by approximately 14%, 12% and 28% respectively. Table 4.5. Reductions were not as great during the winter season, because the waterbody has a greater assimilative capacity when temperatures are lower and DO saturation is higher. Figure 4.10 shows the daily average DO in Bogue Chitto Creek, in which the DO sag of approximately 5.0 mg/L occurs at river mile 27.7. Figure 4.11 shows the daily average DO concentrations in the Unnamed Tributary of Bogue Chitto Creek where the Southern Oaks Subdivision is located. As shown in the figure, the DO in this tributary does not fall below 5.0 mg/L. Since no reductions were necessary in the winter season for sources that discharge into Straight Fence or Limekiln Creeks, the model output is not shown for these reaches.

Table 4.5. Load Reduction Scenario, Winter Conditions

Facility	Flow (cfs)	$CBOD_5$ (mg/L)	$CBOD_5$/ $CBOD_U$ Ratio	$CBOD_U$ (lbs/day)	NH_3-N (mg/L)	$NBOD_U$ (lbs/day)	$TBOD_U$ (lbs/day)	Percent Reduction
Baptist Children's Village	0.093	30	1.5	22.5	2.0	4.6	27.1	0.0
Catfish Haven Restaurant	0.004	45	1.5	1.6	2.0	0.2	1.8	0.0
City of Clinton – Briars POTW	0.975	8	2.3	96.7	2.0	48.0	144.7	14.3
City of Clinton – Northeast POTW	0.464	10	2.3	57.6	2.0	22.9	80.4	0.0
City of Clinton – Lovett POTW	0.427	15	2.3	79.4	2.0	21.0	100.5	0.0
Jackson POTW (Triangle Water Co - Pres. Hill)	1.160	8	1.5	75.1	2.0	57.2	132.2	12.4
Lake Lorman Utility District	0.099	14	1.5	11.2	2.0	4.9	16.1	0.0
Southern Oaks Subdivision	0.011	20	1.5	10.0	2.0	3.1	13.1	27.7
Total for All Facilities				**354.0**		**161.8**	**515.8**	**8.5**

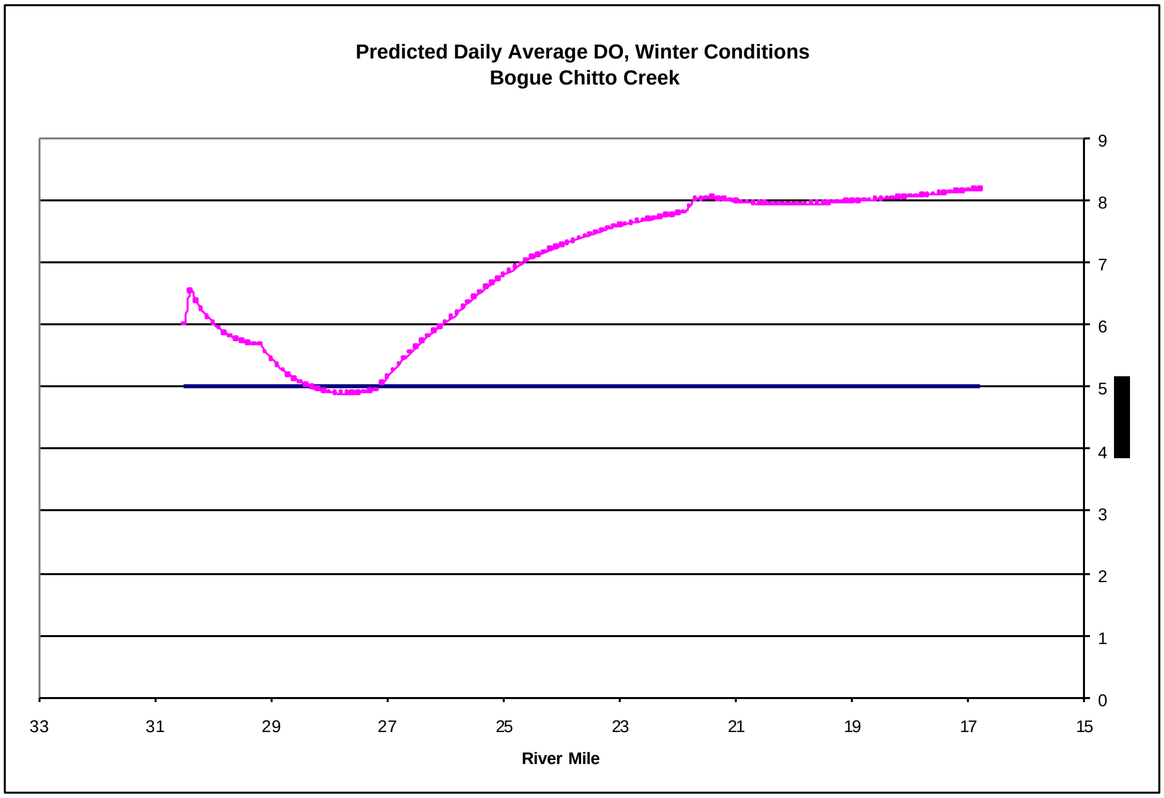

Figure 4.10. Load Reduction Scenario – Winter Model Output, Bogue Chitto Creek

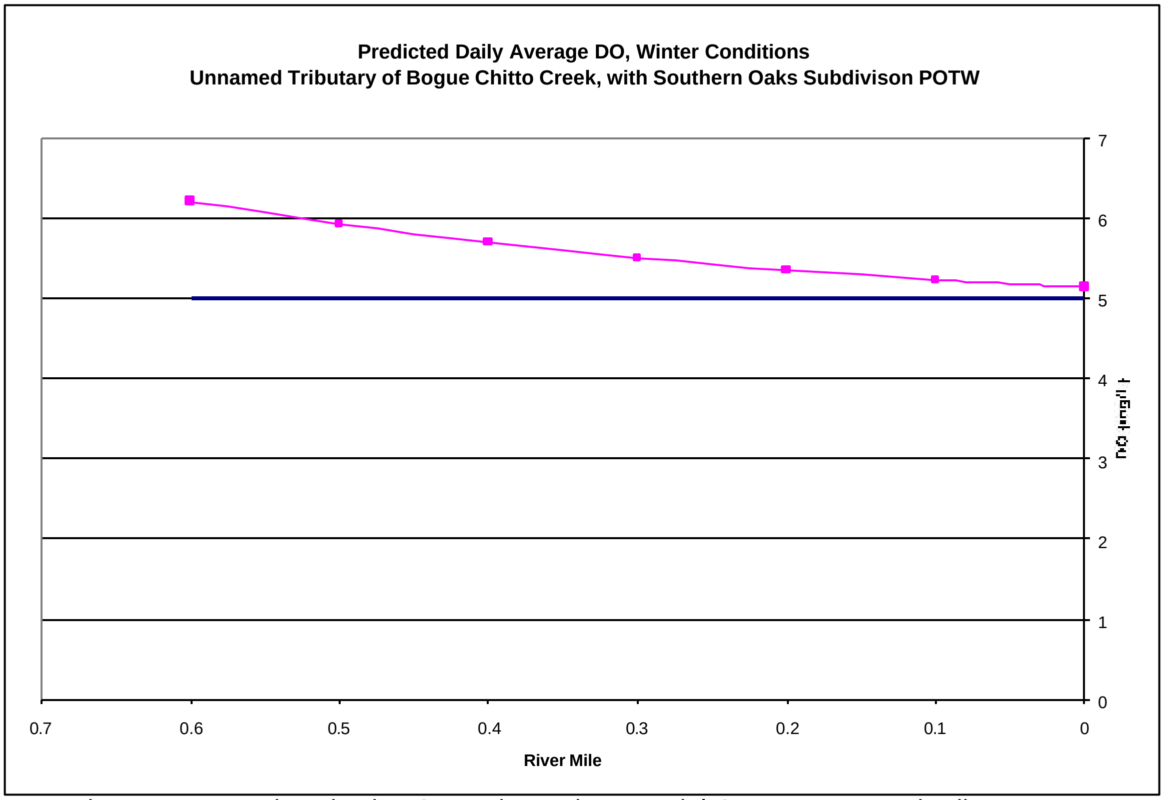

Figure 4.11. Load Reduction Scenario – Winter Model Output, Unnamed Tributary

5.0 Allocation

The allocation for this TMDL involves a wasteload allocation for point sources and a load allocation for nonpoint sources necessary for attainment of water quality standards in segment MS463M. Seasonality was addressed in the TMDL by running the model for both summer and winter conditions. The load and wasteload allocations for Bogue Chitto Creek and its tributaries were developed as seasonal loads, based on the model results for summer and winter conditions.

5.1 Wasteload Allocation

Eight NPDES Permitted facilities in the Bogue Chitto Creek watershed are included in the wasteload allocation. The wasteload allocation in this TMDL includes seasonal loads for $TBOD_U$, Table 5.1. The loads given in Table 5.1 are equal to the load reduction scenarios for the summer and winter seasons given in Tables 4.3 and 4.4. As discussed in Section 4.6, a total reduction of 27% of the permitted $TBOD_U$ load is needed in the summer and 8.5% of the $TBOD_U$ load is needed in the winter. However, wasteload allocations for individual dischargers are not given in this section because they may be changed from the scenarios given in Section 4.6, based on the needs of individual dischargers and water quality response in the receiving waterbodies.

The AWFWUL1 model was used to determine the maximum assimilative capacity of Bogue Chitto Creek, Limekiln Creek, and Straight Fence Creeks for $CBOD_U$ and NH_3-N. In order to convert the NH_3-N loads to an oxygen demand, a factor of 4.57 pounds of oxygen per pound of NH_3-N oxidized to nitrate nitrogen (NO_3-N) was used. The oxygen demand caused by nitrification of ammonia is equal to the $NBOD_U$ load. The sum of $CBOD_U$ and $NBOD_U$ is equal to the wasteload allocation for $TBOD_U$.

Table 5.1 Wasteload Allocations for MS463M

Season	$CBOD_U$ (lbs/day)	$NBOD_U$ (lbs/day)	$TBOD_U$ (lbs/day)
Summer (May – October)	272.5	135.5	**408.0**
Winter (November – April)	354.0	161.8	**515.8**

5.2 Load Allocation

The headwater and spatially distributed loads are included in the load allocation. The $TBOD_U$ concentrations of these loads were determined by using an assumed $CBOD_5$ concentration of 1.33 mg/L and an NH_3-N concentration of 0.1 mg/L. These concentrations should be assumed when reliable field data are not available, according to *Empirical Stream Model Assumptions for Conventional Pollutants and Conventional Water Quality Models* (MDEQ, 1994). The headwater and spatially distributed flows were calculated for the Bogue Chitto Creek watershed by delineating the drainage area into subwatersheds for Bogue Chitto Creek, Limekiln Creek, and Straight Fence Creek. Flows from each subwatershed were based on the 7Q10 flow coefficient for the watershed and the watershed size. Then, the load allocations were calculated to determine the $CBOD_U$ and $NBOD_U$ loads in lbs/day, Table 5.2. Because the load allocation does not vary by season, it is given on an annual basis.

Table 5.2 Load Allocations

Subwatershed	Flow (cfs)	$CBOD_5$ (mg/L)	$CBOD_5$/ $CBOD_U$ Ratio	$CBOD_U$ (lbs/day)	NH_3-N (mg/L)	$NBOD_U$ (lbs/day)	$TBOD_U$ (lbs/day)
Bogue Chitto Creek	0.522	1.33	1.5	5.61	0.1	1.29	6.90
Limekiln Creek	0.288	1.33	1.5	3.10	0.1	0.71	3.81
Straight Fence Creek	0.500	1.33	1.5	5.38	0.1	1.23	6.61
Total				**14.09**		**3.23**	**17.32**

5.3 Incorporation of a Margin of Safety

The margin of safety (MOS) is a required component of a TMDL and accounts for the uncertainty about the relationship between pollutant loads and the quality of the receiving waterbody. The two types of MOS development are to implicitly incorporate the MOS using conservative model assumptions or to explicitly specify a portion of the total TMDL as the MOS. The MOS selected for this model is implicit. Conservative assumptions which place a higher demand of DO on the waterbody than may actually be present are considered part of the margin of safety. The assumption that all of the ammonia nitrogen present in the waterbody is oxidized to nitrate nitrogen, for example, is a conservative assumption.

Another conservative assumption is that the permitted point sources are discharging at their maximum permitted flow and $TBOD_U$ loads, when most of the facilities are actually discharging less than that. This assumption is made in order to set up the model at the worst-case scenario. The effect of making this conservative assumption can be quantified by comparing records of actual discharge to the permit limits of each facility. DMRs for the four largest NPDES Permitted Facilities in the Bogue Chitto Creek watershed were analyzed in order to calculate average $TBOD_U$ loads discharged from each facility. DMRs from January 1998 through April 2001 were used for this calculation. The yearly average loads from the City of Clinton's Lovett, Briars, and Northeast POTWs and the Jackson POTW are shown in Table 5.3. The loads were compared to the maximum permitted loads, and the percent difference between the two values shown can be considered as one of the many components of the implicit MOS.

Table 5.3: Comparison of Permitted and Actual Loads

Facility	Permitted $TBOD_U$ Load (lbs/day)	Actual $TBOD_U$ Load (lbs/day)	Percent Difference
City of Clinton – Briars POTW	168.87	20.23	88.02%
City of Clinton – Lovett POTW	100.45	16.76	83.32%
City of Clinton – Northeast POTW	80.41	30.61	61.93%
Jackson POTW (Triangle Water Co - Pres. Hill)	151.00	29.61	80.39%
Total for Four Facilities	**500.73**	**97.21**	**80.59%**

5.4 Calculation of the TMDL

The TMDL was calculated based on Equation 5.1.

$$\boxed{\textbf{TMDL = WLA + LA + MOS}} \quad \text{(Equation 5.1)}$$

Where WLA is the wasteload allocation, LA is the load allocation, and MOS is the margin of safety. All units are in lbs/day of $TBOD_U$. The TMDLs for $TBOD_U$ were calculated on a seasonal basis, based on the maximum allowable loading of the pollutants in Bogue Chitto Creek and its tributaries, according to the model. The TMDL calculations are shown in Tables 5.4 and 5.5. As shown in the tables, $TBOD_U$ is the sum of $CBOD_U$ and $NBOD_U$. The wasteload allocations incorporate the $CBOD_U$ and NH_3-N contributions from identified NPDES Permitted facilities. The load allocations include the headwaters and spatially distributed $TBOD_U$ and NH_3-N contributions from surface runoff and groundwater infiltration. The implicit margin of safety for this TMDL is derived from the conservative assumptions used in setting up the model.

Table 5.4. TMDL for $TBOD_U$, for Summer Conditions (May – October)

	WLA (lbs/day)	LA (lbs/day)	MOS	TMDL (lbs/day)
$CBOD_U$	272.5	14.1	Implicit	286.6
$NBOD_U$	135.5	3.2	Implicit	138.7
$TBOD_U$	**408.0**	**17.3**	Implicit	**425.3**

Table 5.5. TMDL for $TBOD_U$, for Winter Conditions (November - April)

	WLA (lbs/day)	LA (lbs/day)	MOS	TMDL (lbs/day)
$CBOD_U$	354.0	14.1	Implicit	368.1
$NBOD_U$	161.8	3.2	Implicit	165.0
$TBOD_U$	**515.8**	**17.3**	Implicit	**531.1**

6.0 CONCLUSION

This Phase I TMDL, will place restrictions on NPDES permitting activities in Bogue Chitto Creek and its tributaries, including Limekiln and Straight Fence Creeks, such that no increase in the current $TBOD_U$ load specified in existing permits will be allowed. Also, no NPDES permits for new facilities will be issued for the Bogue Chitto Creek Watershed until additional data have been collected and a Phase II TMDL has been completed. Furthermore, steps need to be taken to ensure that the overall load of $TBOD_U$ placed in this waterbody from point and nonpoint sources does not exceed the waterbody's assimilative capacity. The maximum load of $TBOD_U$, as determined by this Phase I TMDL, is 425.3 lbs/day in the summer and 531.1 lbs/day in the winter. The current load in the waterbody, based on maximum NPDES permit limits, is 560.6 lbs/day in the summer and 568.3 lbs/day in the winter. Thus, a reevaluation of these permits will be necessary before the next permit reissuance cycle. The reevaluation must ensure that the permitted loads combined with the nonpoint source loads do not exceed the assimilative capacity of the waterbody.

Because this Phase I TMDL is based on many assumptions and literature values in place of actual field data, MDEQ will give permit holders the opportunity to discuss the results of this TMDL before any reductions to existing permit limits are made. MDEQ will allow permit holders to provide additional data regarding their wastewater treatment facilities and the condition of the waterbodies that they discharge into. MDEQ will consider all pertinent data provided by the permit holders and will develop a Phase II TMDL before making reductions to current permit limits.

6.1 Future Monitoring

MDEQ has adopted the Basin Approach to Water Quality Management, a plan that divides Mississippi's major drainage basins into five groups. During each yearlong cycle, MDEQ's resources for water quality monitoring will be focused on one of the basin groups. During the next monitoring phase in the Big Black Basin, Bogue Chitto Creek will receive additional monitoring to identify any change in water quality. In addition, MDEQ is planning to collect additional information about current landuse and nonpoint sources in the watershed for development of a Phase II TMDL.

It is recognized that the organic material contribution from nonpoint sources may be under represented in the Phase I TMDL. This is due to lack of information available for quantifying nonpoint source loads. In addition, the model used to calculate the TMDL was run for low-flow critical conditions when nonpoint source loadings are minimal. Detailed information on nonpoint source contributions and the use of a dynamic watershed model which represents a wide range of flow conditions will be necessary in order to accurately represent nonpoint source contributions in the model and the TMDL calculation.

Remote sensing is one of the most efficient ways to study nonpoint source pollutant loads in a watershed. Because remote sensing refers to acquisition of information about an object without physical contact, it can often be used in place of extensive on-the-ground sampling. Aerial photography acquisition and interpretation is one type of remote sensing that has been used to study and quantify nonpoint sources. Aerial photography has been used successfully in several previous TMDL projects in Mississippi. The process involves acquiring color, infrared aerial photographs of a watershed according to a predetermined flight pattern. The photo interpretation process consists of identification of landuse types in the watershed as well as soil loss estimates, location of livestock operations, stream order, drainage conditions, road locations and conditions, locations of onsite septic systems, impervious areas, riparian conditions, and geological features. From the landuse and other features identified in the photo interpretation, loadings of organic material and sediment can be estimated. MDEQ plans to use this type of approach to quantify nonpoint source loadings for the Phase II TMDL.

6.2 Public Participation

This TMDL will be published for a 30-day public notice. During this time, the public will be notified by publication in the statewide newspaper. The public will be given an opportunity to review the TMDL and submit comments. At the end of the 30-day period, MDEQ will determine the level of interest in the TMDL and make a decision on the necessity of holding a public hearing. If a public hearing is deemed appropriate, the public will be given a 30-day notice of the hearing to be held at a location near the watershed. That public hearing would be an official hearing of the Mississippi Commission on Environmental Quality, and would be transcribed.

All comments received during the public notice period and at any public hearings become a part of the record of this TMDL. All comments will be considered in the submission of this TMDL to EPA Region 4 for final approval.

REFERENCES

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DEFINITIONS

5-Day Biochemical Oxygen Demand: Also called BOD_5, the amount of oxygen consumed by microorganisms while stabilizing or degrading carbonaceous or nitrogenous compounds under aerobic conditions over a period of 5 days.

Activated Sludge: A secondary wastewater treatment process that removes organic matter by mixing air and recycled sludge bacteria with sewage to promote decomposition

Aerated Lagoon: A relatively deep body of water contained in an earthen basin of controlled shape which is equipped with a mechanical source of oxygen and is designed for the purpose of treating wastewater.

Ammonia: Inorganic form of nitrogen (NH_3); product of hydrolysis of organic nitrogen and denitrification. Ammonia is preferentially used by phytoplankton over nitrate for uptake of inorganic nitrogen.

Ammonia Nitrogen: The measured ammonia concentration reported in terms of equivalent ammonia concentration; also called total ammonia as nitrogen (NH_3-N)

Ammonia Toxicity: Under specific conditions of temperature and pH, the unionized component of ammonia can be toxic to aquatic life. The unionized component of ammonia increases with pH and temperature.

Ambient Stations: A network of fixed monitoring stations established for systematic water quality sampling at regular intervals, and for uniform parametric coverage over a long-term period.

Assimilative Capacity: The capacity of a body of water or soil-plant system to receive wastewater effluents or sludge without violating the provisions of the State of Mississippi Water Quality Criteria for Intrastate, Interstate, and Coastal Waters and Water Quality regulations.

Background: The condition of waters in the absence of man-induced alterations based on the best scientific information available to MDEQ. The establishment of natural background for an altered waterbody may be based upon a similar, unaltered or least impaired, waterbody or on historical pre-alteration data.

Biological Impairment: Condition in which at least one biological assemblages (e.g. , fish, macroinvertabrates, or algae) indicates less than full support with moderate to severe modification of biological community noted.

Carbonaceous Biochemical Oxygen Demand: Also called CBODu, the amount of oxygen consumed by microorganisms while stabilizing or degrading carbonaceous compounds under aerobic conditions over an extended time period.

Calibrated Model: A model in which reaction rates and inputs are significantly based on actual measurements using data from surveys on the receiving waterbody.

Conventional Lagoon: An un-aerated, relatively shallow body of water contained in an earthen basin of controlled shape and designed for the purpose of treating water.

Critical Condition: Hydrologic and atmospheric conditions in which the pollutants causing impairment of a waterbody have their greatest potential for adverse effects.

Daily Discharge: The "discharge of a pollutant" measured during a calendar day or any 24-hour period that reasonably represents the calendar day for purposes of sampling. For pollutants with limitations expressed in units of mass, the "daily discharge" is calculated as the total mass of the pollutant discharged over the day. For pollutants with limitations expressed in other units of measurement, the "daily average" is calculated as the average.

Designated Use: Use specified in water quality standards for each waterbody or segment regardless of actual attainment.

Discharge Monitoring Report: Report of effluent characteristics submitted by a NPDES Permitted facility.

Dissolved Oxygen: The amount of oxygen dissolved in water. It also refers to a measure of the amount of oxygen that is available for biochemical activity in a water body. The maximum concentration of dissolved oxygen in a waterbody depends on temperature, atmospheric pressure, and dissolved solids.

Dissolved Oxygen Deficit: The saturation dissolved oxygen concentration minus the actual dissolved oxygen concentration.

DO Sag: Longitudinal variation of dissolved oxygen representing the oxygen depletion and recovery following a waste load discharge into a receiving water.

Effluent Standards and Limitations: All State or Federal effluent standards and limitations on quantities, rates, and concentrations of chemical, physical, biological, and other constituents to which a waste or wastewater discharge may be subject under the Federal Act or the State law. This includes, but is not limited to, effluent limitations, standards of performance, toxic effluent standards and prohibitions, pretreatment standards, and schedules of compliance.

Effluent: Treated wastewater flowing out of the treatment facilities.

First Order Kinetics: Describes a reaction in which the rate of transformation of a pollutant is proportional to the amount of that pollutant in the environmental system.

Groundwater: Subsurface water in the zone of saturation. Groundwater infiltration describes the rate and amount of movement of water from a saturated formation.

Impaired Waterbody: Any waterbody that does not attain water quality standards due to an individual pollutant, multiple pollutants, pollution, or an unknown cause of impairment.

Land Surface Runoff: Water that flows into the receiving stream after application by rainfall or irrigation. It is a transport method for nonpoint source pollution from the land surface to the receiving stream.

Load Allocation (LA): The portion of a receiving water's loading capacity attributed to or assigned to nonpoint sources (NPS) or background sources of a pollutant

Loading: The total amount of pollutants entering a stream from one or multiple sources.

Mass Balance: An equation that accounts for the flux of mass going into a defined area and the flux of mass leaving a defined area, the flux in must equal the flux out.

Nonpoint Source: Pollution that is in runoff from the land. Rainfall, snowmelt, and other water that does not evaporate become surface runoff and either drains into surface waters or soaks into the soil and finds its way into groundwater. This surface water may contain pollutants that come from land use activities such as agriculture; construction; silvaculture; surface mining; disposal of wastewater; hydrologic modifications; and urban development.

Nitrification: The oxidation of ammonium salts to nitrites via *Nitrosomonas* bacteria and the further oxidation of nitrite to nitrate via *Nitrobacter* bacteria.

Nitrogenous Biochemical Oxygen Demand: Also called NBODu, the amount of oxygen consumed by microorganisms while stabilizing or degrading nitrogenous compounds under aerobic conditions over an extended time period.

NPDES Permit: An individual or general permit issued by the Mississippi Environmental Quality Permit Board pursuant to regulations adopted by the Mississippi Commission on Environmental Quality under Mississippi Code Annotated (as amended) §§ 49-17-17 and 49-17-29 for discharges into State waters.

Photosynthesis: The biochemical synthesis of carbohydrate based organic compounds from water and carbon dioxide using light energy in the presence of chlorophyll.

Point Source: Pollution loads discharged at a specific location from pipes, outfalls, and conveyance channels from either wastewater treatment plants or industrial waste treatment facilities. Point sources can also include pollutant loads contributed by tributaries to the main receiving stream.

Pollution: Contamination, or other alteration of the physical, chemical, or biological properties, of any waters of the State, including change in temperature, taste, color, turbidity, or odor of the waters, or such discharge of any liquid, gaseous, solid, radioactive, or other substance, or leak into any waters of the State, unless in compliance with a valid permit issued by the Permit Board.

Publicly Owned Treatment Works (POTW): A waste treatment facility owned and/or operated by a public body or a privately owned treatment works which accepts discharges which would otherwise be subject to Federal Pretreatment Requirements.

Reaeration: The net flux of oxygen occurring from the atmosphere to a body of water across the water surface.

Regression Coefficient: An expression of the functional relationship between two correlated variables that is often empirically determined from data, and is used to predict values of one variable when given values of the other variable.

Respiration: The biochemical process by means of which cellular fuels are oxidized with the aid of oxygen to permit the release of energy required to sustain life. During respiration, oxygen is consumed and carbon dioxide is released.

Sediment Oxygen Demand: The solids discharged to a receiving water are partly organics, which upon settling to the bottom decompose aerobically, removing oxygen from the surrounding water column.

Storm Runoff: Rainfall that does not evaporate or infiltrate the ground because of impervious land surfaces or a soil infiltration rate than rainfall intensity, but instead flows into adjacent land or waterbodies or is routed into a drain or sewer system.

Streeter-Phelps DO Sag Equation: An equation which uses a mass balance approach to determine the DO concentration in a waterbody downstream of a point source discharge. The equation assumes that the stream flow is constant and that CBODu exertion is the only source of DO deficit while reaeration is the only sink of DO deficit.

Total Ultimate Biochemical Oxygen Demand: Also called TBODu, the amount of oxygen consumed by microorganisms while stabilizing or degrading carbonaceous or nitrogenous compounds under aerobic conditions over an extended time period.

Total Kjeldahl Nitrogen: Also called TKN, organic nitrogen plus ammonia nitrogen.

Total Maximum Daily Load or TMDL: The calculated maximum permissible pollutant loading to a waterbody at which water quality standards can be maintained.

Waste: Sewage, industrial wastes, oil field wastes, and all other liquid, gaseous, solid, radioactive, or other substances which may pollute or tend to pollute any waters of the State.

Wasteload Allocation (WLA): The portion of a receiving water's loading capacity attributed to or assigned to point sources of a pollutant.

Water Quality Standards: The criteria and requirements set forth in *State of Mississippi Water Quality Criteria for Intrastate, Interstate, and Coastal Waters*. Water quality standards are standards composed of designated present and future most beneficial uses (classification of waters), the numerical and narrative criteria applied to the specific water uses or classification, and the Mississippi antidegradation policy.

Water Quality Criteria: Elements of State water quality standards, expressed as constituent concentrations, levels, or narrative statements, representing a quality of water that supports the present and future most beneficial uses.

Waters of the State: All waters within the jurisdiction of this State, including all streams, lakes, ponds, wetlands, impounding reservoirs, marshes, watercourses, waterways, wells, springs, irrigation systems, drainage systems, and all other bodies or accumulations of water, surface and underground, natural or artificial, situated wholly or partly within or bordering upon the State, and such coastal waters as are within the jurisdiction of the State, except lakes, ponds, or other surface waters which are wholly landlocked and privately owned, and which are not regulated under the Federal Clean Water Act (33 U.S.C.1251 et seq.).

Watershed: The area of land draining into a stream at a given location.

ABBREVIATIONS

7Q10............................Seven-Day Average Low Stream Flow with a Ten-Year Occurrence Period

BASINS.................................Better Assessment Science Integrating Point and Nonpoint Sources

BMP ....Best Management Practice

$CBOD_5$ ....5-Day Carbonaceous Biochemical Oxygen Demand

$CBOD_U$..Carbonaceous Ultimate Biochemical Oxygen Demand

CWA ....Clean Water Act

DMR...Discharge Monitoring Report

EPA ....Environmental Protection Agency

GIS .... Geographic Information System

HUC ....Hydrologic Unit Code

LA..Load Allocation

MARIS ....Mississippi Automated Resource Information System

MDEQ ....Mississippi Department of Environmental Quality

MGD..Million Gallons per Day

MOS..Margin of Safety

$NBOD_U$ ....Nitrogenous Ultimate Biochemical Oxygen Demand

NH_3 .... Total Ammonia

NH_3-N ....Total Ammonia as Nitrogen

NO_2+ NO_3... Nitrite Plus Nitrate

NPDES ....National Pollution Discharge Elimination System

RBA...Rapid Biological Assessment

$TBOD_5$ ....5-Day Total Biochemical Oxygen Demand

$TBOD_U$..Total Ultimate Biochemical Oxygen Demand

TKN .... Total Kjeldahl Nitrogen

TN ....Total Nitrogen

TOC...Total Organic Carbon

TP ....Total Phosphorous

USGS...United States Geological Survey

WLA..Waste Load Allocation